Diagnosing the Distribution of Seasonal Mean Precipitation

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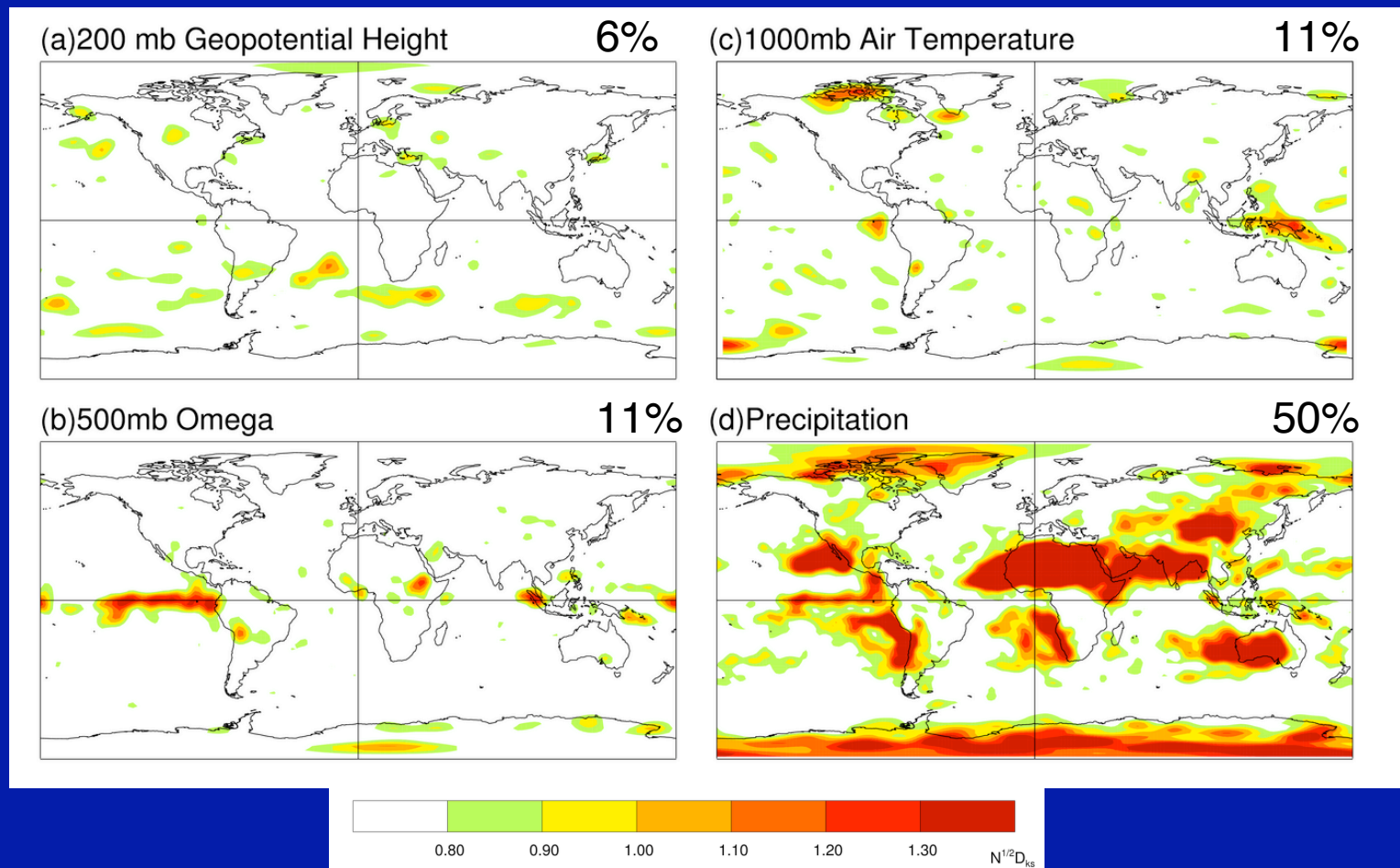
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Introduction

1. What governs the PDF of seasonal mean precipitation?

2. Using GCM and reanalysis data, *Sardeshmukh, Compo, and Penland* (2000) suggested that the PDF is non-Gaussian in regions of large-scale tropospheric descent.

3. Descending areas are also drought-prone areas. Need to understand the shape of the PDF in these areas in particular.

4. As a first step, we have computed skewness and the fit to a Gaussian using the Kolmogorov-Smirnov (Lillifoer's) distance D_{ks}.
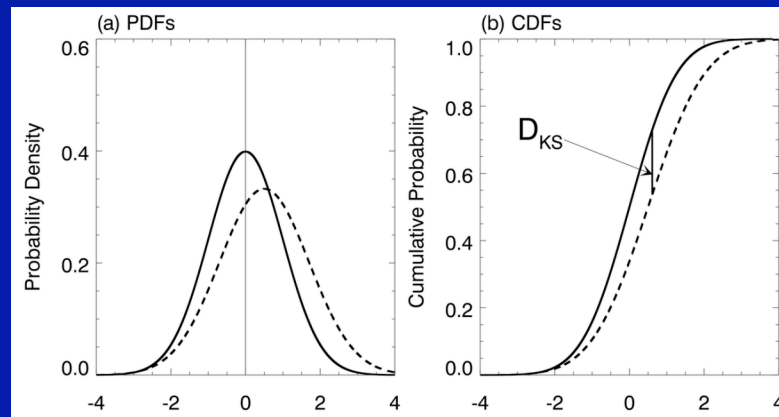
Non-Gaussian regions for January-March Seasonal Means
(NCEP-NCAR Reanalysis, 1948-2004)

(a) 200 mb Geopotential Height — 6%

(b) 500mb Omega — 11%

(c) 1000mb Air Temperature — 11%

(d) Precipitation — 50%

0.80   0.90   1.00   1.10   1.20   1.30 $N^{1/2}D_{ks}$

While many variables are Gaussian,
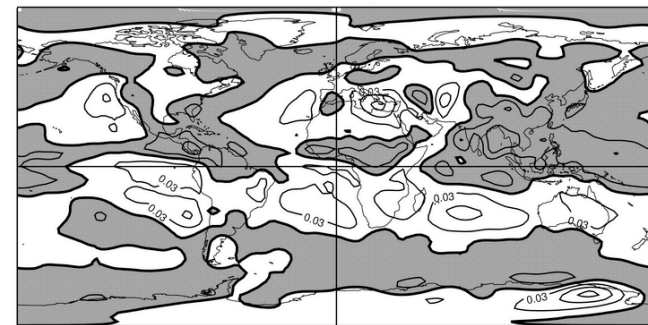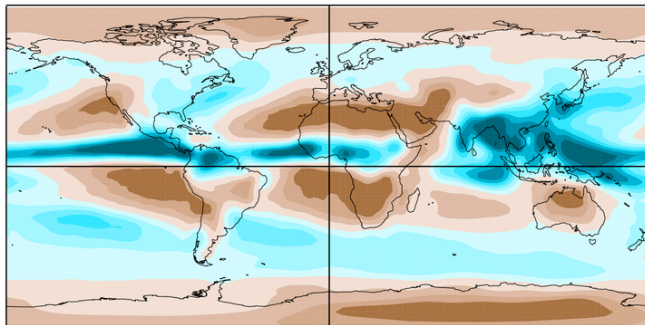precipitation is not, over 50% of the globe.

Climatology of Seasonal Mean Precipitation and 500 mb Vertical Velocity

JFM

JJA
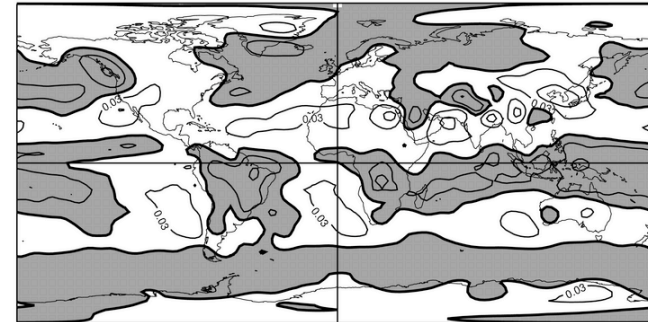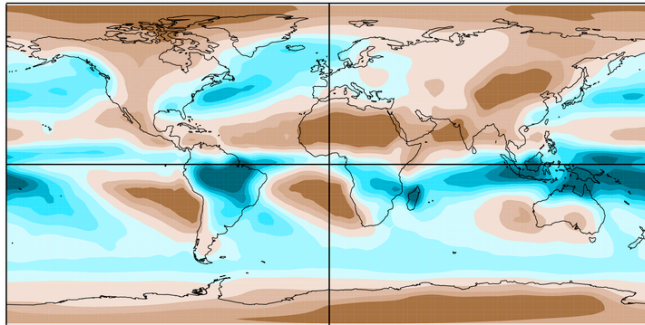
Shading indicates mean ascent

0.0 0.25 0.5 1.0 1.5 2.0 3.0 4.0 5.0 6.0 7.0 8.0 mm/day

Global Precipitation Climatology Project

NCEP-NCAR Reanalysis

Precipitation is non-Gaussian in colored areas.
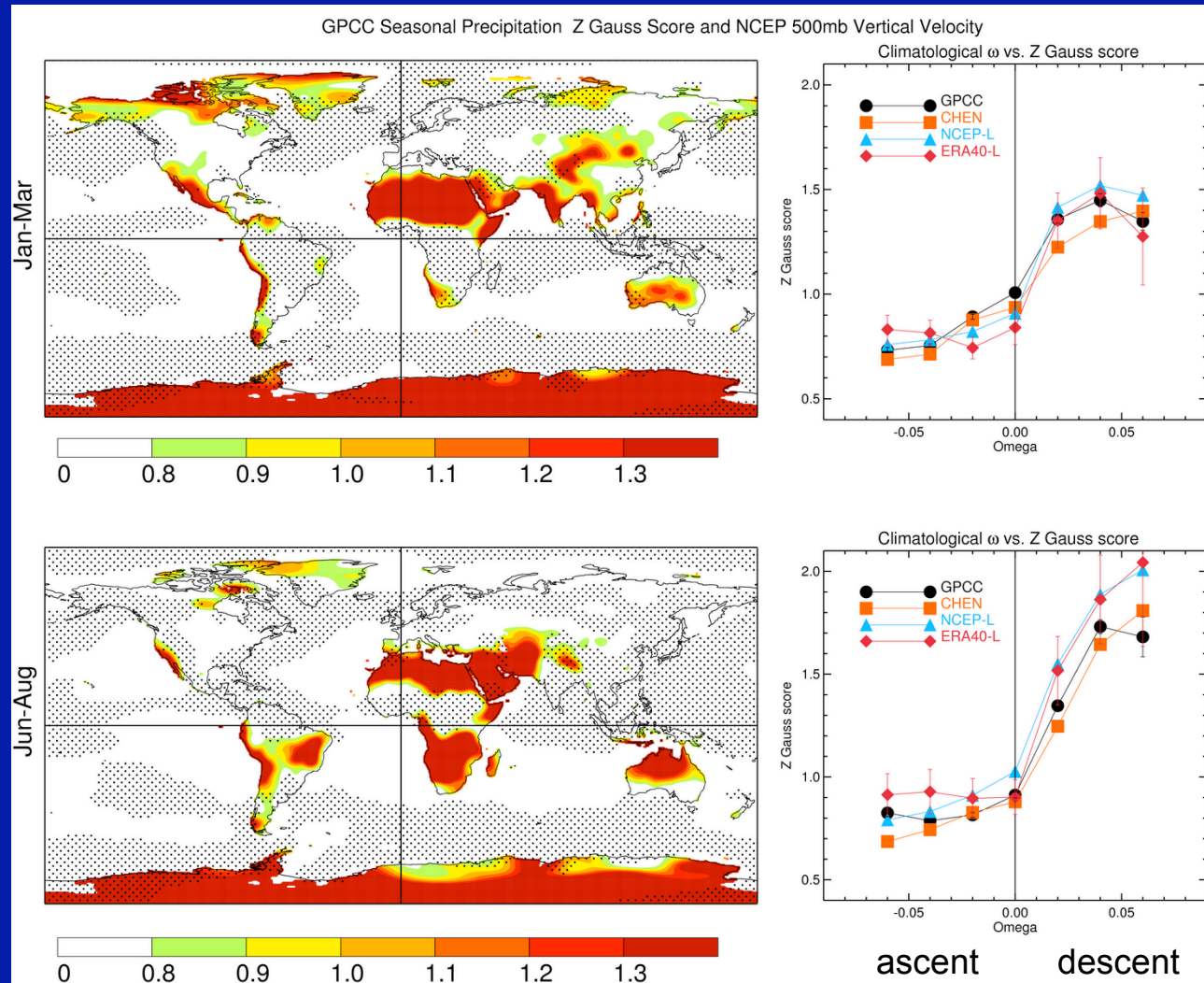# These are also areas of mean descent (right panels).

GPCP
Precipitation,
NCEP-NCAR
500 mb Vertical
Velocity
(1979-2004)

GPCP Seasonal Precipitation Z Gauss Score and NCEP 500mb Vertical Velocity
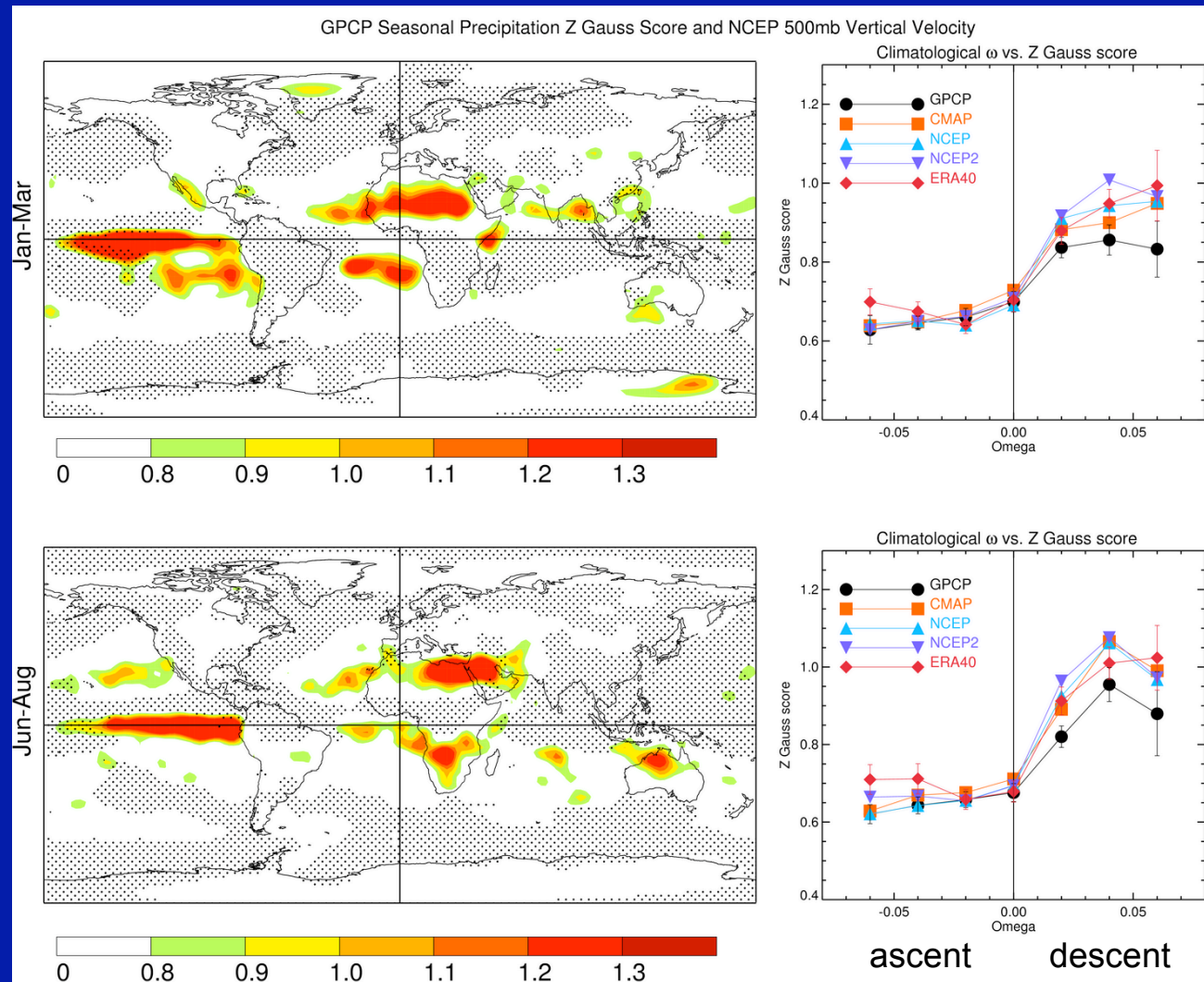
Stippled areas show regions of climatological mean ascent

Precipitation is non-Gaussian in colored land areas.
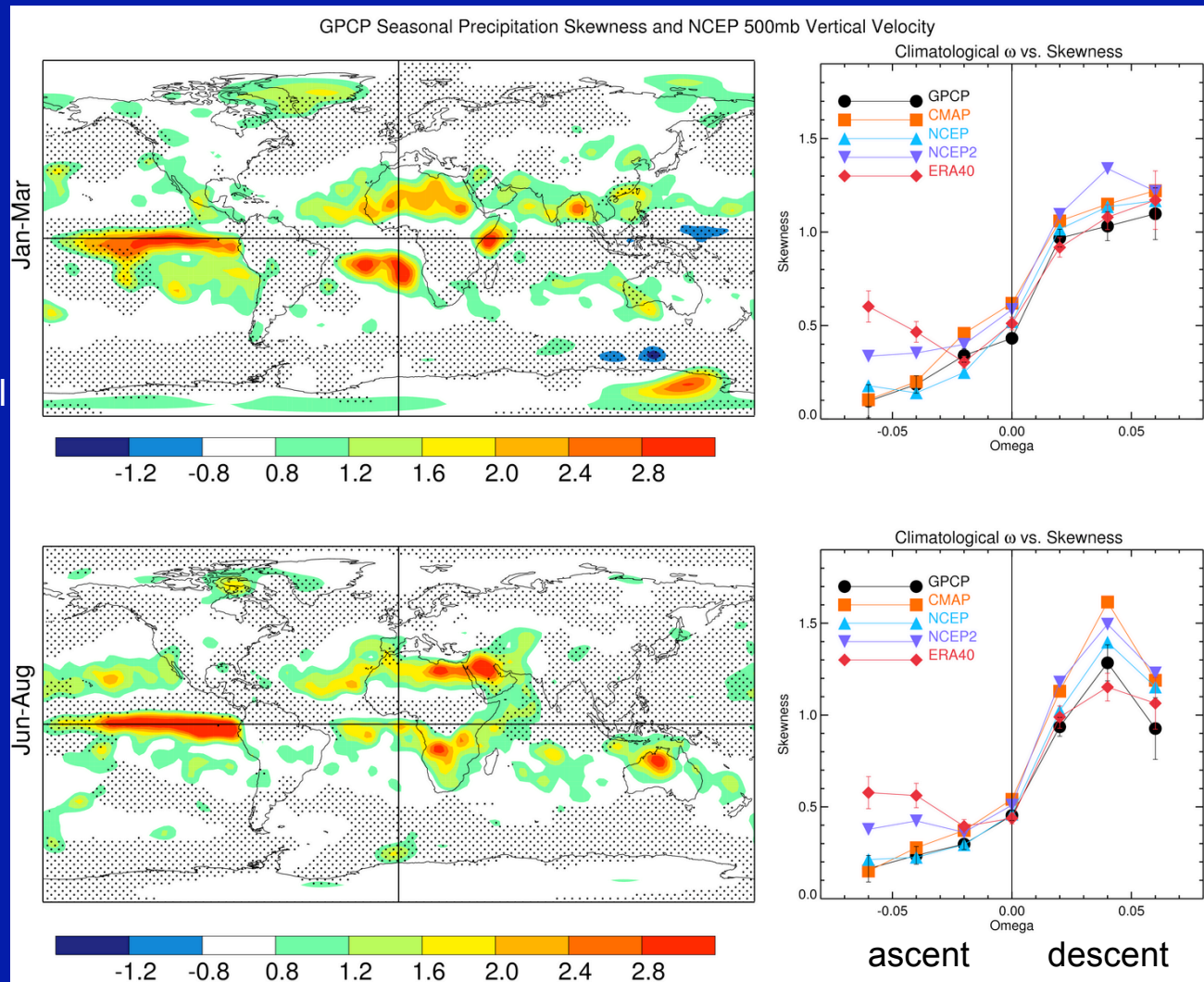# These are also areas of mean descent (right panels).

GPCC
Precipitation,
NCEP-NCAR
500 mb Vertical
Velocity
(1951-2004)

GPCC Seasonal Precipitation Z Gauss Score and NCEP 500mb Vertical Velocity

Stippled areas show regions of climatological mean ascent

Precipitation is skewed in colored areas.
Positive skew occurs in regions of mean descent (right panels).

GPCP
Precipitation,
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500 mb Vertical
Velocity
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Stippled areas show regions of climatological mean ascent

Precipitation is skewed in colored land areas.
Positive skew occurs in regions of mean descent (right panels).

GPCC
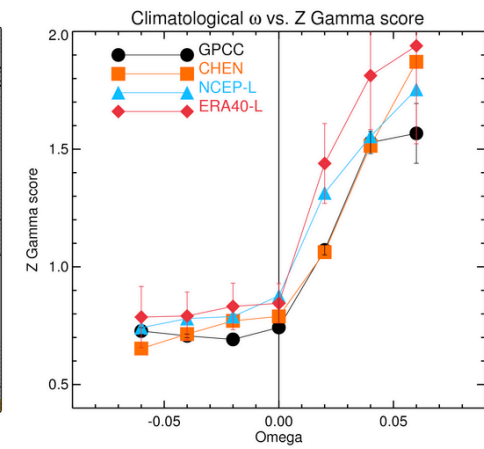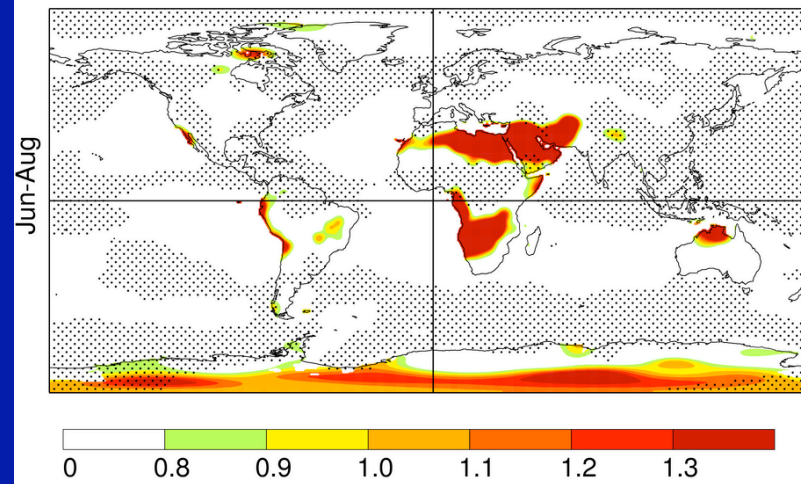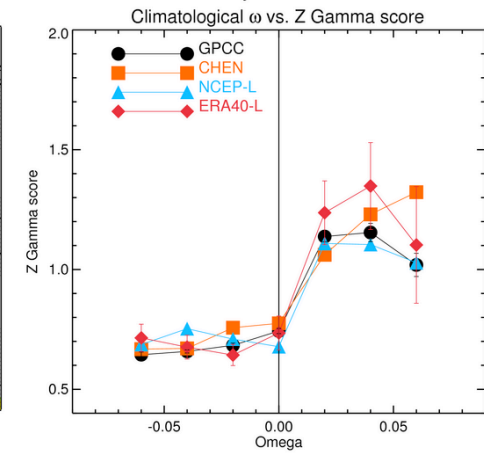Precipitation,
NCEP-NCAR
500 mb Vertical
Velocity
(1951-2004)

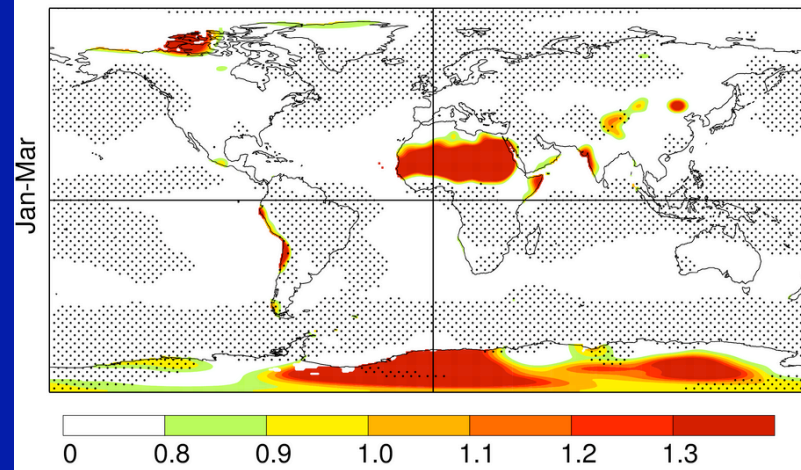GPCC Seasonal Precipitation Skewness and NCEP 500mb Vertical Velocity
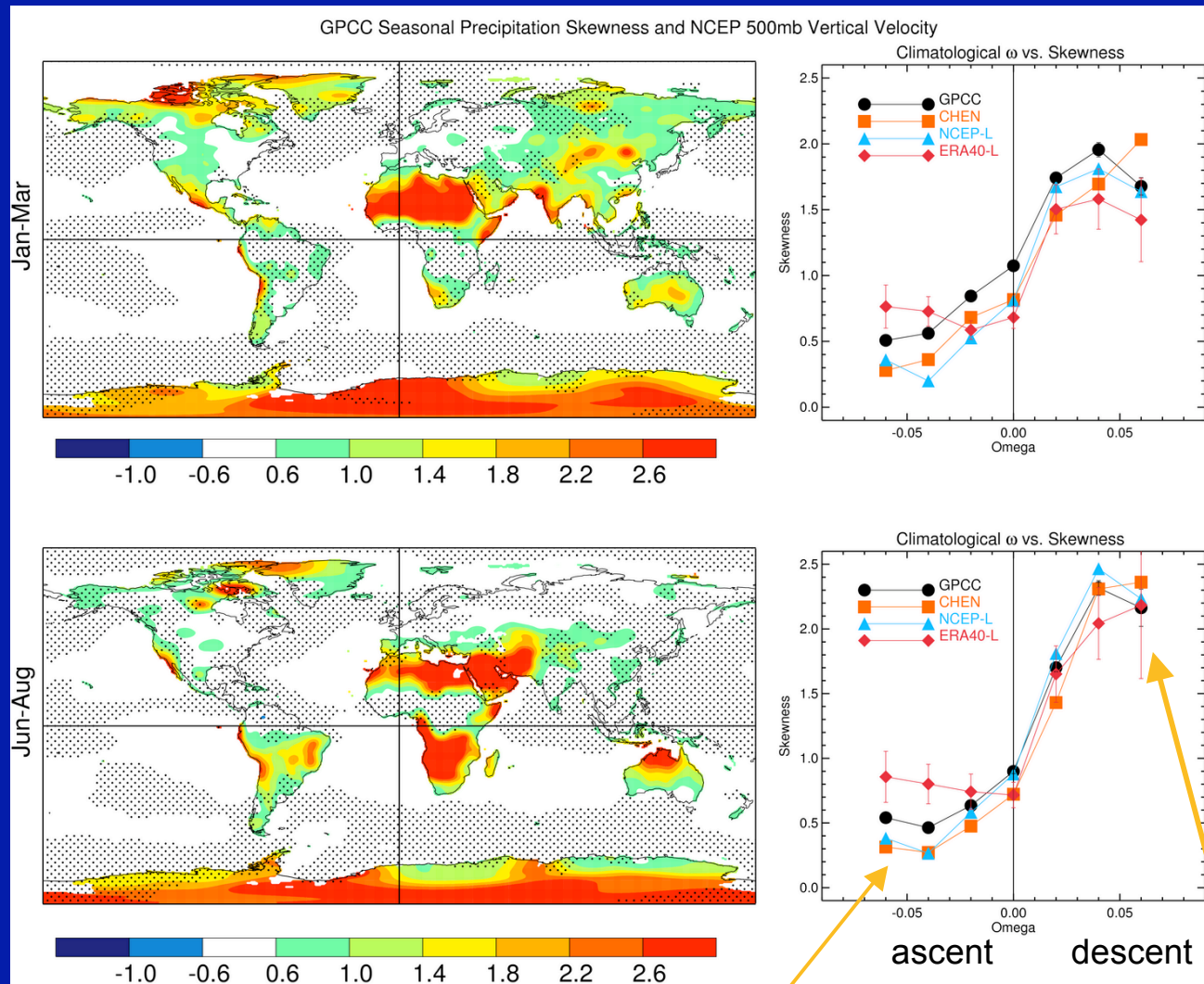
3 to 4 times more skewed in regions of mean descent

Conclusions

1. Even seasonal mean precipitation is significantly non-Gaussian (and non-Gamma) in semi-arid regions of descent.

2. A general theory for the shape of the precipitation PDF must account for large-scale ascent and descent, which are influenced by remote forcing.
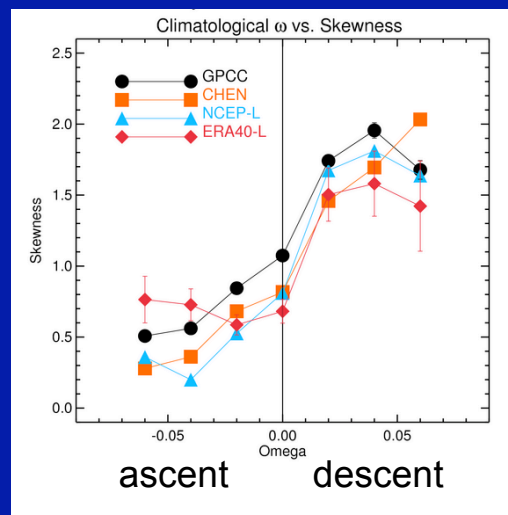
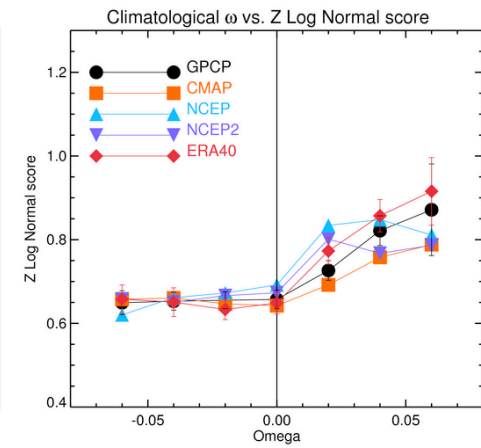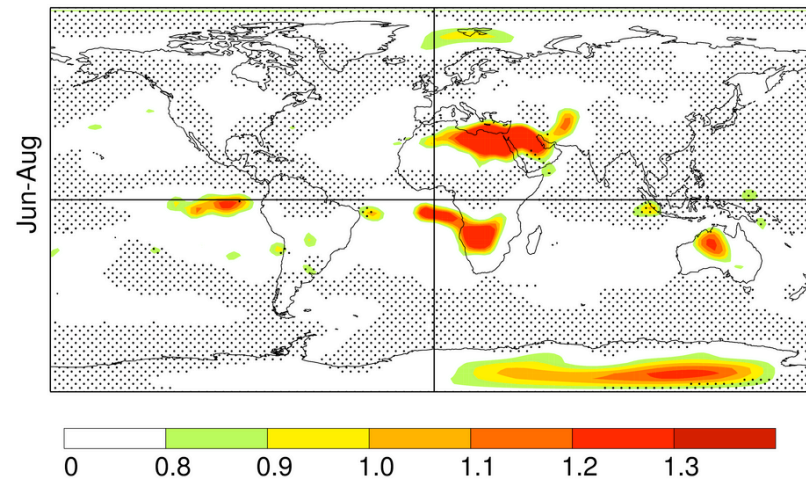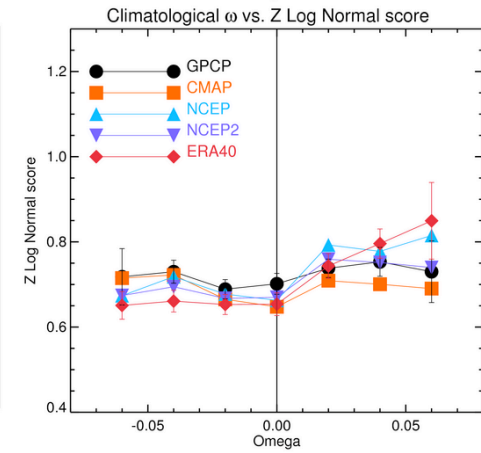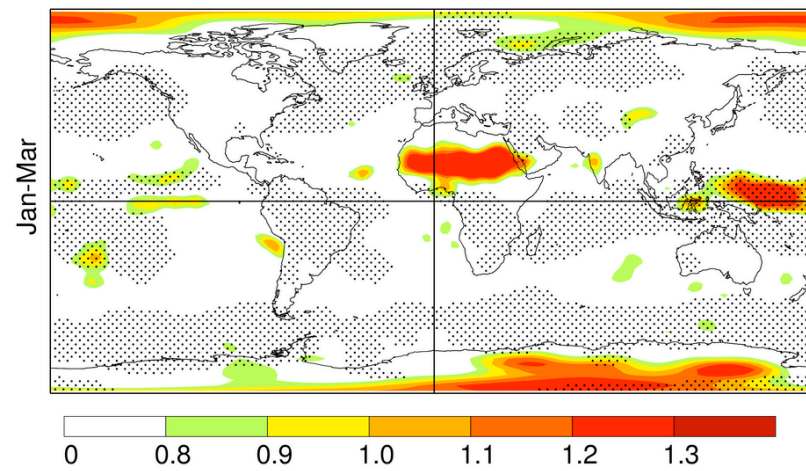Climatological ω vs. Skewness

ascent   descent

GPCC Seasonal Precipitation Z Gamma Score and NCEP 500mb Vertical Velocity

GPCP Seasonal Precipitation Z Gamma Score and NCEP 500mb Vertical Velocity
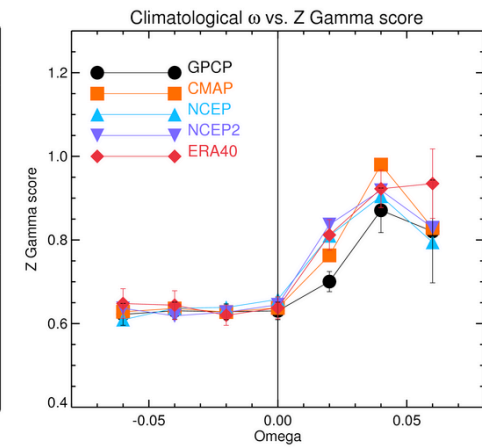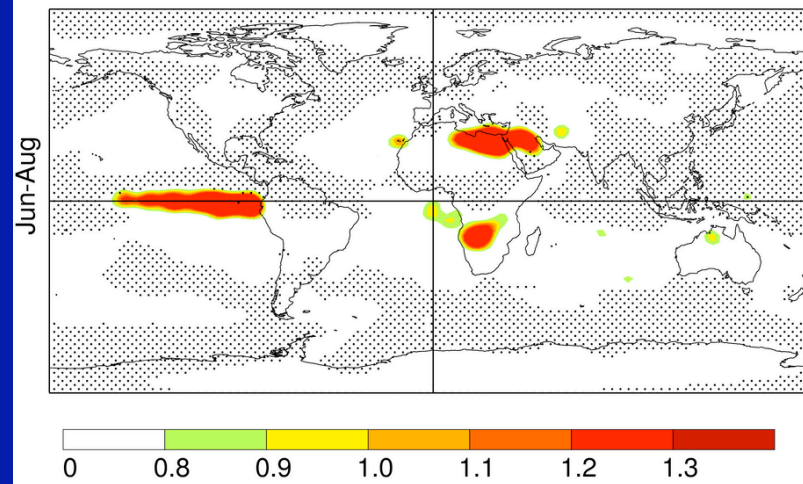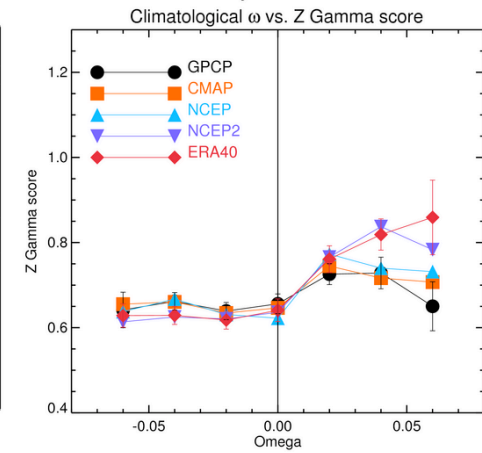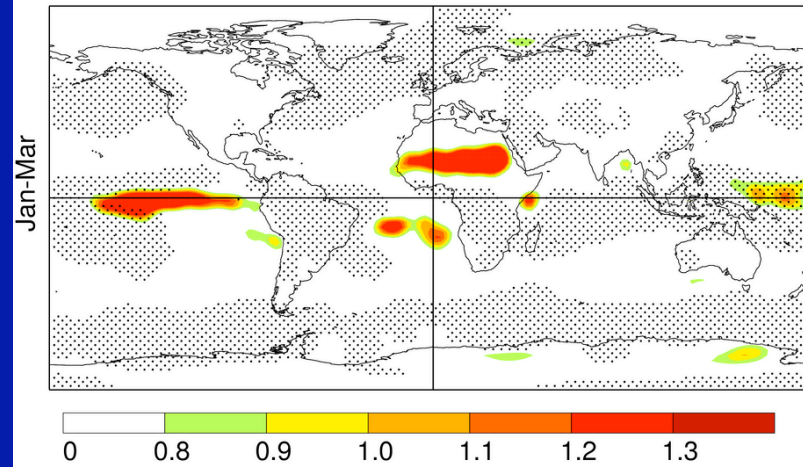
GPCP Seasonal Precipitation Z Log Normal Score and NCEP 500mb Vertical Velocity

GPCC Seasonal Precipitation Z Log Normal Score and NCEP 500mb Vertical Velocity